ELP305-Submission-02: Cleaning Machine Requirements and Specifications

Tribe B

Tribe B Team Member Details

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Table 7: Research Team Members Details with IF < 1

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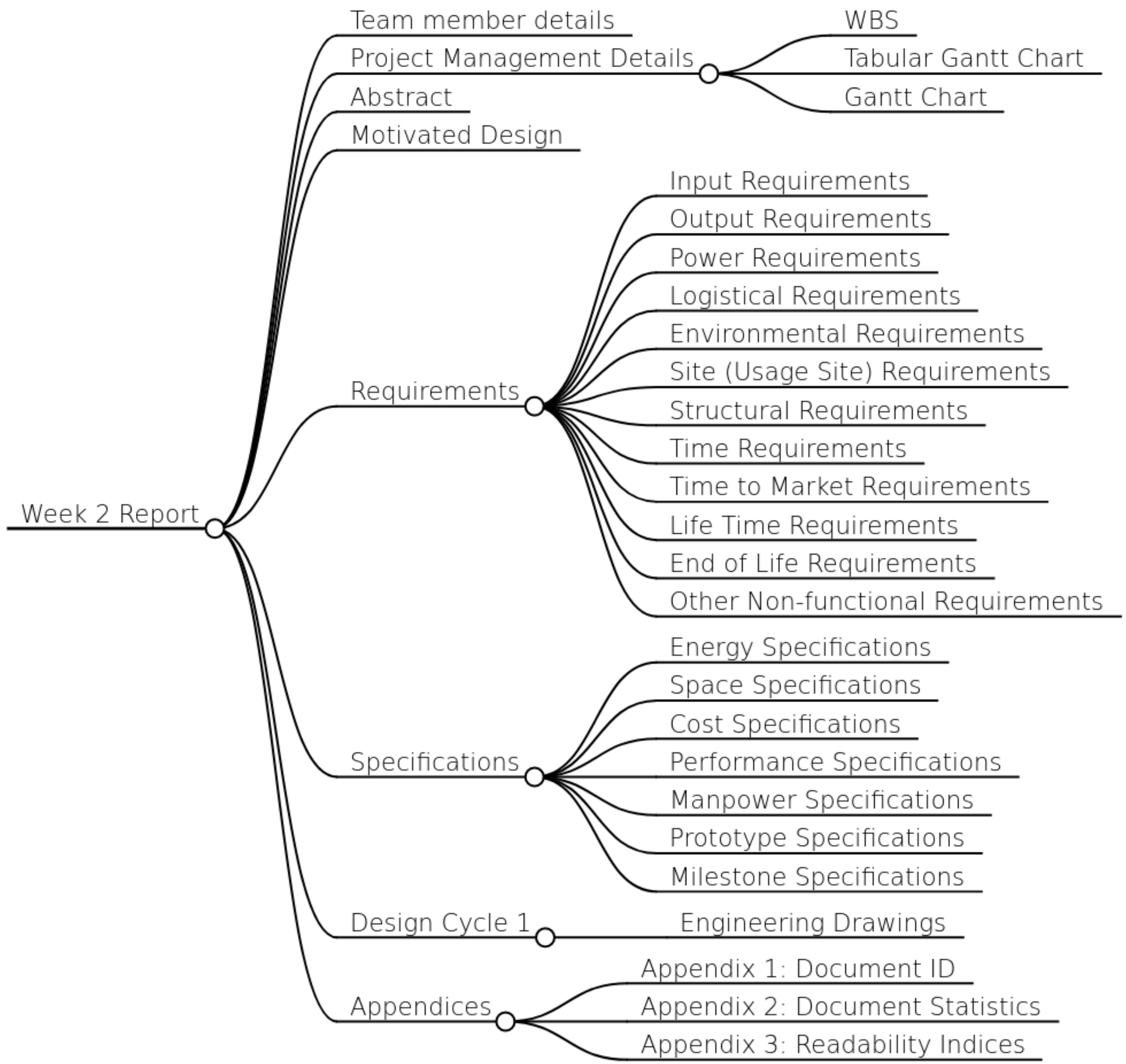

Figure 1: Document Outline Mindmap

Abstract

The design document outlines a comprehensive approach to creating a cleaning machine tailored for white unbleached cotton fabric. The fabric specifications include a new, 400- thread count, 60-denier cotton fabric with a dry weight of 11 kgs to be washed in a 45-minute single cleaning cycle. The machine is designed to accommodate a maximum fabric width of 2 meters, ensuring efficiency and practicality. Environmental considerations are integrated into the design, utilizing non-toxic, biodegradable detergents for wet cleaning, aligning with sustainability standards. The machine's structural components, such as the rotating drum and water mist-steam cleaning module, are strategically designed to optimize the cleaning efficacy while preserving fabric integrity. The machine's operational features include an integrated system for introducing wet cleaning chemicals at specific stages, ensuring precise timing to maximize effectiveness while minimizing adverse effects on fabric quality. The use of a Programmable Logic Controller (PLC) and a Human-Machine Interface (HMI) enhances operational control and user interaction. In terms of efficiency, the tumble drying process[10] is highlighted, utilizing a rotating drum [12] with hot air circulation. The machine structure is outlined, encompassing inner and outer components, sensors, pumps, valves, and safety features. Regular cleaning and maintenance considerations are incorporated to manage lint buildup and ensure long-term reliability. The fabric and machine specifications are meticulously addressed, considering factors such as tear strength, temperature range, flammability, power load preferences, and batch size. The design emphasizes adaptability to different cleaning methods (water, dry, air) and remains cost-effective while adhering to a maximum power load of 1-phase 220V 15A or 3-phase 440V 8A.

1 Project Management Details

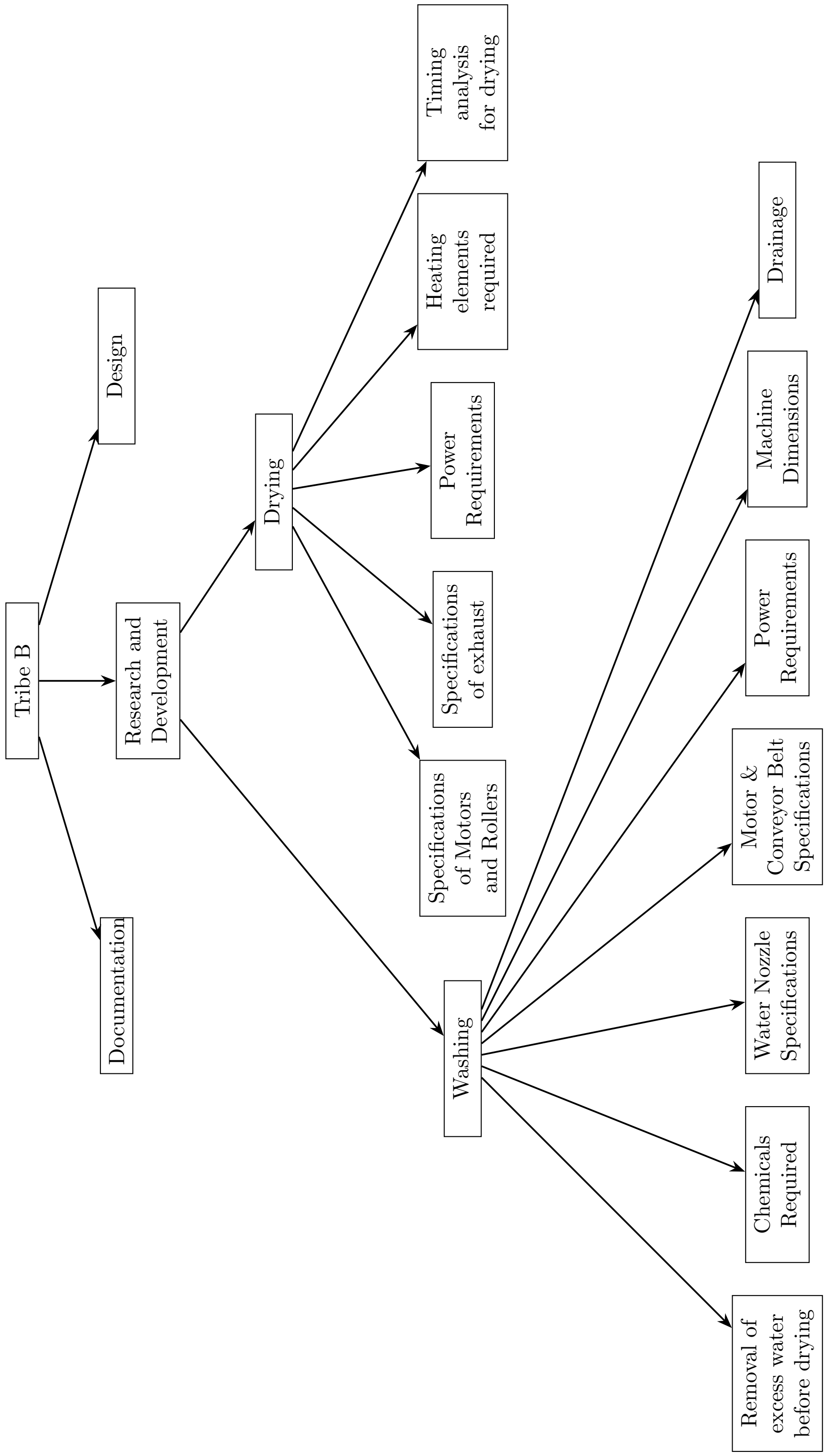

Figure 2: WBS

	Name	Duration	Start	Finish	Predecessors
1	Full Team	10 days	3/1/24 11:00 AM	17/1/24 11:00 AM	None
2	Team Formation & Logistics	1 day	3/1/24 11:00 AM	4/1/24 11:00 AM	None
3	Requirements Question...	2 days	3/1/24 11:00 AM	5/1/24 11:00 AM	None
4	S1 Review	2 days	15/1/24 11:00 AM	17/1/24 11:00 AM	None
5	Research & Development	9.5 days	5/1/24 11:00 AM	18/1/24 4:00 PM	None
6	Requirements Research	3 days	5/1/24 11:00 AM	10/1/24 11:00 AM	3
7	Specifications Research	1.5 days	17/1/24 11:00 AM	18/1/24 4:00 PM	4
8	Documentation	7.625 days	10/1/24 11:00 AM	19/1/24 5:00 PM	None
9	S1 Report	1.5 days	10/1/24 11:00 AM	11/1/24 4:00 PM	6
10	S1 Proofreading	0.75 days	11/1/24 11:00 AM	12/1/24 9:00 AM	None
11	S2 Report	1 day	18/1/24 4:00 PM	19/1/24 4:00 PM	7
12	S2 Proofreading	0.5 days	19/1/24 1:00 PM	19/1/24 5:00 PM	None
13	Design & Fabrication	0.5 days	18/1/24 4:00 PM	19/1/24 11:00 AM	None
14	Design Finalisation & CAD	0.5 days	18/1/24 4:00 PM	19/1/24 11:00 AM	7

Table 8: Tabular Gantt Chart

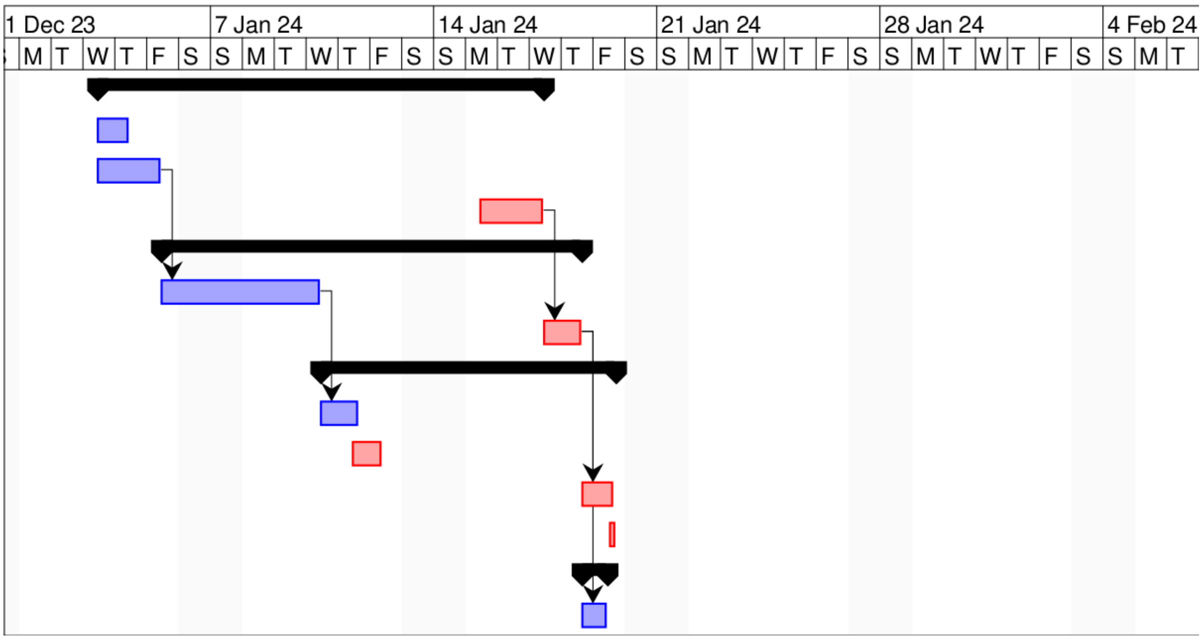

Figure 3: Gantt Chart

2 Motivated Design: Synergizing Wet Cleaning with Spray Washing

Our inspiration for the Cotton Fabric Cleaning Machine stemmed from the client's specific need to clean new white unbleached cotton fabric, emphasizing a packaging cleaning solution for fabric manufacturers. To meet these demands effectively, our design strategically integrates the proven benefits of Wet Cleaning with the advanced features of Spray Washing [13].

Motivated by the desire to optimize stain removal, fabric preservation, and overall cleaning efficacy, we seamlessly blended Wet Cleaning's non-toxic, biodegradable detergents with the precision of a Spray Washing Machine. This innovative approach not only addresses manufacturing impurities but also enhances the machine's capabilities for odor removal and environmental friendliness.

Understanding the importance of versatility, the design accommodates various cleaning methods, including water, dry, and air, ensuring adaptability to different fabric handling needs. The motivation to adhere to power load preferences further ensures cost-effectiveness and safety in operation.

The user-centric design principles are rooted in the desire for efficiency and ease of operation. The 45-minute single cleaning cycle and a balanced machine size cater to the client's need for practicality and a user-friendly experience.

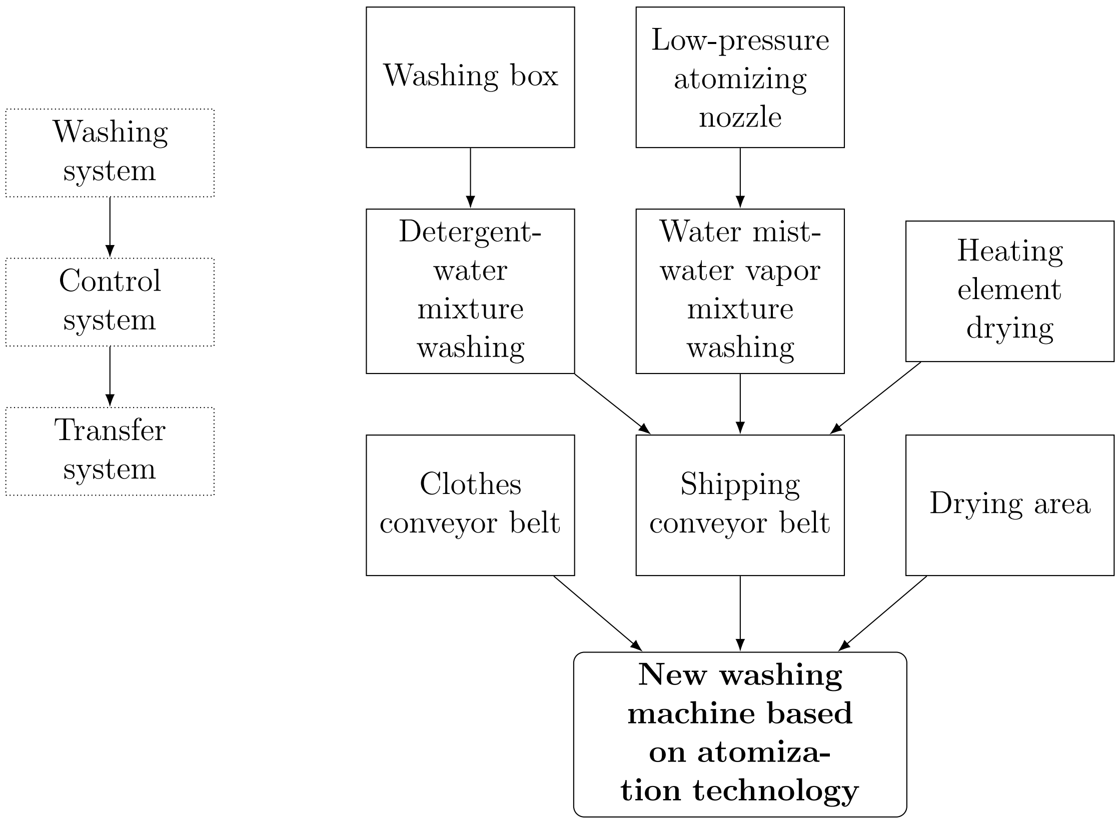

Figure 4: Machine Design Mindmap

Economically driven, the design is cost-effective, aligning with budgetary constraints while adhering to environmental standards, as mandated by CPCB rules. In essence, our motivation behind this integrated design is to provide a holistic fabric care solution that not only meets but exceeds client expectations through the seamless synergy of Wet Cleaning and Spray Washing technologies.

3 Requirements

3.1 Input Requirements

3.1.1 Water Requirements

To wash 11 kgs of cotton cloth, we will require around 80-90 liters of water.

3.1.2 Detergent Requirements

Considering an 11 kg of cotton fabric, our design recommends using 500 ml of Surf Excel Matic Front Load Liquid Detergent. With 5 liters of detergent, nearly 10-11 cotton fabrics can be efficiently washed, making it a cost-effective and resource-efficient choice.

3.1.3 Input Requirements - Summary

Key Consideration	**Requirement**
Types of stains or fabrics the machine should be optimized for	White unbleached Cotton fabric which has been just manufactured
The intended user of the cleaning machine	The entity who made the unbleached cotton fabric
Desired fiber content of the fabrics	Single ply, thread count 400 and denier 60
Types of yarn commonly used in the fabrics to be cleaned	Cotton yarn
Maximum dimensions of the fabrics that the cleaning machine should accommodate	10 meter length x 2 meters width
Fabric's colorfastness to laundering	Colours are fast, they do not run. Primarily the input is NOT coloured - white unbleached cotton cloth
Specific requirements for abrasion resistance, especially for fabrics that may undergo frequent cleaning cycles	None. Each fabric undergoes one cleaning and is then packed
Minimum tear strength specifications	125 kg (tensile method test)
Is seam slippage a critical factor, and if so, the acceptable levels for the fabrics	No, the edges of the fabric are back-folded seams
Flammability characteristics of the fabric	Flammable if exposed to naked flame for more than 6 seconds
Stains/impurity industry specifically added during the manufacturing process that need to be cleaned	No, stains are not deliberately added. Only impurities are the materials used to manufacture the cloth

Table 9: Input Requirements

3.2 Output Requirements

3.2.1 Drainage System

The size of the drainage pipe is chosen based on the expected flow rate of water and chemicals during the washing process. A larger valve allows for quicker drainage, which is particularly important in a commercial setting. Size: 2-3 inches in diameter (based on flow rate calculation). Material: Stainless steel or corrosion-resistant plastic.

3.2.2 Ventilation

We will be using the exhaust of around 4 inches in diameter considering the CFM. Approximate space that the exhaust and duct will cover is 16x16 cm.

3.3 Power Requirements

3.3.1 Machine Power Use

Pump for Nozzles, Motor of conveyor Belt, heating water, Control Panel(Timers, Sensors) Power Supply Needed - 180V - 240V Motor for conveyor belt: 74.57 Watt Pump for Nozzles: 1hp(745 Watt) (Approx value of power needed for pump to fulfill our need)

3.3.2 Power requirement for drying

Actual drying times and energy usage can vary based on factors such as the changing environmental factors and the moisture content of the cloth. According to our analysis of the thermodynamics of our system, the power required will be around 2000 watts.

3.4 Logistical Requirements

3.4.1 Adequate space for the entire machine

The machines need sufficient space for installation and proper functioning. The assembly would require approximately an area of 3x5 meters

3.4.2 Water supply connection

An essential logistical requirement for the washing process, the water supply ensures the availability of the medium for wet cleaning agents. 80-90 Liters of water will be required for one batch

3.4.3 Ventilation for efficient drying

Proper ventilation is crucial during the drying process to facilitate the efficient removal of moisture from the fabric.

3.5 Environmental Requirements

3.5.1 Good ventilation for efficient drying

Beyond its role in efficient drying, good ventilation also contributes to environmental considerations by optimizing energy efficiency during the tumble drying process.

3.5.2 Humidity monitoring system

Machine's efficiency depends a lot on the humidity levels so efficient humidity management through ventilation would be required

3.6 Site (Usage Site) Requirements

3.6.1 Well-ventilated space for drying

The drying process requires a well-ventilated space to ensure optimal conditions for moisture removal.

3.6.2 Access to water and power supply

A necessary site requirement for the washing process, ensuring a constant supply of water for the wet cleaning agents.

3.6.3 Proper installation of inner components in machine structures

Ensuring proper installation of inner components is vital for the overall functionality of the machines.

3.7 Structural Requirements

3.7.1 Sturdy housing for the spray washing machine

Sturdy housing is crucial to provide stability and durability for both machines. The rationale is to ensure the machines can withstand the mechanical movements and operational demands without compromising performance.

3.7.2 Adequate support for inner components in machine structures

Proper support for inner components is necessary to prevent malfunctions and maintain the overall integrity of the machines. The rationale is to ensure that all components are well-supported and can perform their functions optimally.

3.8 Time Requirements

3.8.1 Design Time Requirement

Drawing insights from prevalent industry benchmarks in designing cleaning machines for unbleached cotton fabric, our objective is to streamline the design process within a timeframe of around 4 weeks. This aims not just to meet but to surpass contemporary design efficiency, employing innovative methodologies for optimal system performance.

3.8.2 Time to Market Requirements

Comparative analysis of industry timelines underscores the variability in design-to-market durations for cleaning machines. Our commitment is to adhere to or potentially outstrip these norms, ensuring our systems reach the market promptly to address evolving demands through precision and efficient collaboration.

3.8.3 Life Time Requirements

Acknowledging the diverse operational lifespans of machines in the industry, our focal point is to gain a competitive advantage by delivering robust systems with prolonged operational life. Through meticulous design and stringent quality assurance, our aim is to set new industry benchmarks in system longevity.

3.8.4 End of Life Requirements

In navigating the stages of disposal, recycling, and maintenance, industry practices exhibit variability. In our commitment to environmental responsibility, we envision surpassing standard guidelines. As the project progresses, our goal is to introduce procedures that not only meet but exceed existing industry standards, elevating the sustainability and lifecycle management of our systems.

3.9 Other Non-functional Requirements

3.9.1 Safety

Implementation of safety features such as emergency stop buttons and safety sensors. The rationale is to prioritize user safety during the operation of the machines, minimizing the risk of accidents or malfunctions.

3.9.2 Serviceability

Access panels provided for maintenance ease. The rationale is to facilitate easy maintenance and servicing, allowing technicians or users to access internal components for repairs or cleaning without significant disruption.

3.9.3 Reliability

Consistent and reliable performance is essential for effective cleaning and drying. The rationale is to build machines that users can trust to deliver consistent results, meeting their fabric care needs reliably.

3.9.4 Efficient Water Flow Regulation

Control of water inflow and outflow for optimal usage. The rationale is to ensure that water is utilized efficiently during the washing process, contributing to resource conservation and cost-effectiveness.

3.9.5 Turbidity Control

Monitoring and control of water turbidity for effective cleaning. The rationale is to maintain the clarity of water during the washing process, enhancing the performance of wet cleaning agents and improving overall cleaning efficacy.

3.9.6 Inlet and Outlet Timing

Optimal timings for water inlet and outlet during different phases of the cleaning process. The rationale is to synchronize water flow with specific stages of the cleaning cycle, optimizing the effectiveness of detergents and rinsing.

3.9.7 PLC for Operation Control

Use of a Programmable Logic Controller for efficient operation control. The rationale is to implement advanced control systems that enhance the precision and automation of the cleaning and drying processes, ensuring consistent and controlled performance.

3.9.8 HMI for User Interface and Monitoring

Incorporation of a Human-Machine Interface for user-friendly interaction and monitoring. The rationale is to provide users with an intuitive interface to control and monitor the cleaning and drying processes, enhancing the overall user experience.

3.9.9 Environmental Considerations

The overall system design takes into account environmental impact and sustainability, incorporating elements such as biodegradable detergents, effluent treatment, and energy-efficient processes. The rationale is to align the system with modern environmental standards and practices.

3.9.10 Effluent treatment System

Ensures responsible management of wastewater, minimizing environmental impact. The rationale is to address environmental concerns related to wastewater disposal and contribute to sustainable and responsible fabric care practices.

3.9.11 Regular Cleaning and Maintenance Time

Design includes provisions for regular cleaning and maintenance to prevent issues such as lint buildup and ensure long-term functionality. The rationale is to promote proactive maintenance, extending the operational life of the machines and preventing potential breakdowns.

3.10 Chemical Cleaning Methods Mindmap

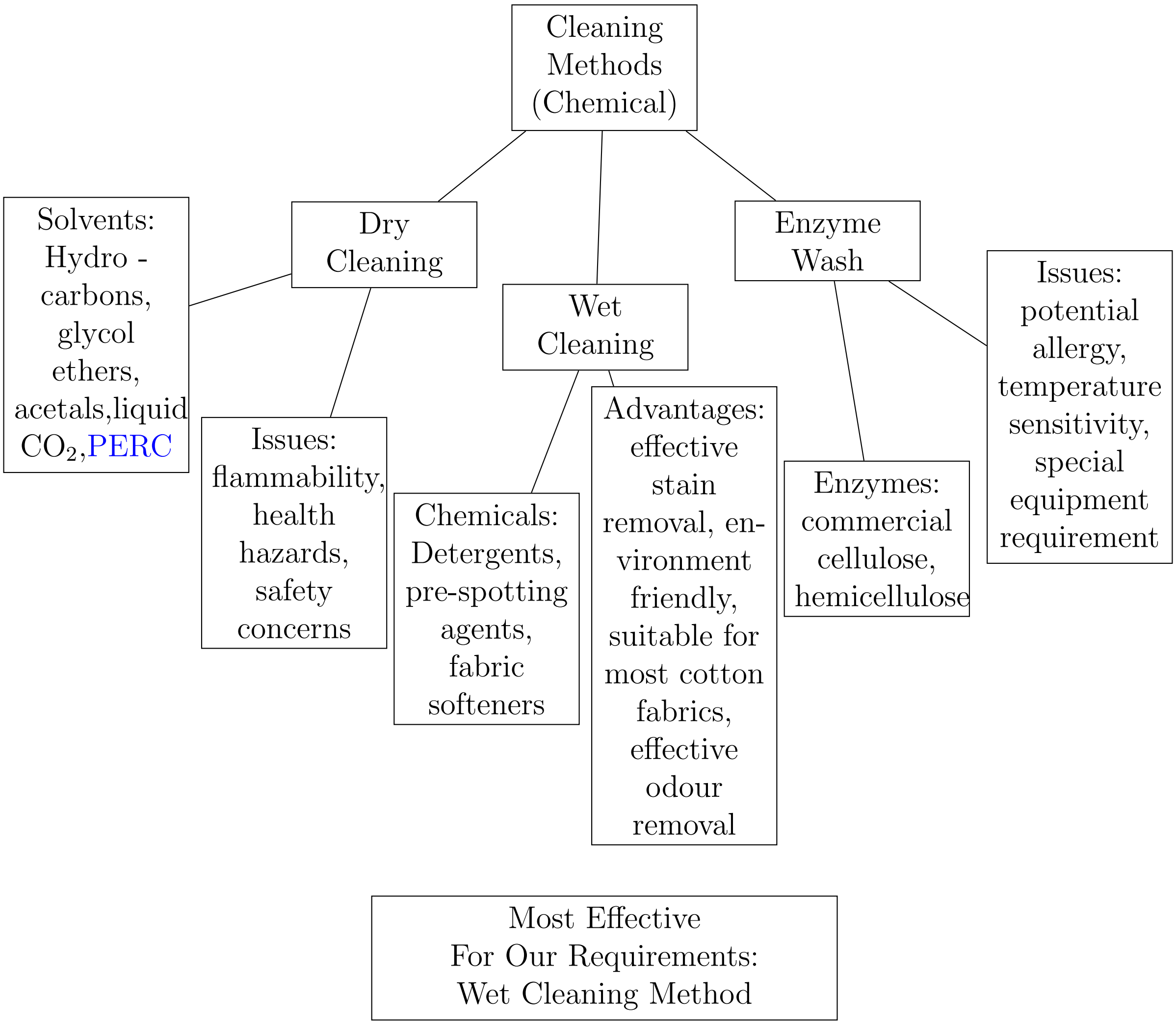

Figure 5: Thought process through which team narrowed down to one cleaning technique from all the possible techniques

4 Specifications

4.1 Energy Specifications

4.1.1 Water Nozzles

1. **Pump for Nozzles:** A 1 hp (745 Watt) pump is the approximate power needed to fulfill our requirements for the nozzles [1].

4.1.2 Motor and Conveyor belt

1. The total weight to be driven by the motors is 1500 kg and the required speed is 0.25 m/min. Assuming a coefficient of friction of 0.5, the total pull is calculated to be $1500 \times 0.25 \times 0.5 = 200$ kgm/min (approximately, including margin).

2. 1 hp is equivalent to 4500 kgm/min.

3. The total weight of the belt ranges from 1500-3000 kg, depending on the belt's thickness, which varies between 5 mm and 10 mm.

4. Motor specifications range from 0.08 to 0.1 horsepower for a speed of 25 cm/min.

5. The energy requirements are for 0.08 horsepower motors running for 45-50 minutes, resulting in an energy consumption of 0.05 kWh per motor.

4.1.3 Drying

Actual drying times and energy usage can vary based on factors such as environmental conditions and the moisture content of the fabric. Our thermodynamic analysis suggests that the power required for drying will be around 2000 Watt [9].

4.1.4 Exhaust System for Drying Chamber

The exhaust system requires a voltage of 240V and a power wattage of 40 Watts.

4.2 Space Specifications

4.2.1 Conveyor belt

1. The conveyor belt is made of general-purpose rubber with a density of $1150\,\mathrm{kg\,m^{-3}}$.
2. The length of the belt is approximately 12 meters.
3. The width of the belt is 2.2 meters.
4. The thickness of the belt ranges from 5 to 10 mm.

4.2.2 Machine Dimensions

1. The machine is 2.2 meters wide.
2. It has a height of 1 meter, with the conveyor belt approximately 0.5 meters above the ground, water nozzles and chemical sprays at a height of 0.5 meters above the conveyor belt, and the drying compartment also at 0.5 meters in height.
3. The length of the machine is 3.5 meters, divided into a 2.5-meter conveyor belt for washing and a 1-meter long drying compartment.

4.3 Cost Specifications

4.3.1 Chemicals used for washing

1. For efficient and cost-effective washing, we recommend Surf Excel Matic Front Load Liquid Detergent. The estimated cost for washing one piece of clothing, including 500 ml of detergent and 300 gm of soda ash for water softening, is Rs 142 [11].
2. With 5 L of detergent, approximately 10-11 cotton fabrics can be washed. The cost of 500 ml Surf Excel Matic detergent is Rs 130. Therefore, the cost requirement for 10 such clothes would be Rs 1300.
3. For 1 piece of clothing: 500 ml of liquid detergent + 300 gm of soda ash, the total cost is Rs 130 + Rs 12 = Rs 142.

4.3.2 Water Nozzles

The cost of water nozzles ranges from Rs 300-500 per nozzle [4].

4.3.3 Motor and Conveyor Belt

1. The cost of the belt is Rs 4500 per meter (2 meters wide), totaling Rs 50,000 for 10-11 meters.
2. The cost of a motor is Rs 5000 [2].

4.3.4 Heating Element Cost

Nichrome is a cost-effective heating element, offering a balance between efficiency and affordability, with an estimated cost of Rs 1800 per kg [8, 3].

4.3.5 Rollers Cost

The cost for rollers is Rs 15,000 per piece, with the price varying depending on the diameter. We require stainless steel rollers due to their corrosion resistance and good mechanical properties over a wide range of temperatures [6].

4.3.6 Exhaust Cost

The exhaust costs around Rs 1800, and the duct made of aluminum will cost Rs 720.

4.3.7 Assembly Cost

The aluminium body around Rs 6000, and the cost of fittings and other components will be around Rs 2500.

4.3.8 Software Cost

Our team uses FreeCAD for both CAD drawings and simulations, resulting in zero software costs.

4.3.9 Total estimated cost for machines

1. 7-8 nozzles for washing and 7-8 nozzles for rinsing along with 5 sprinklers for chemical action cost 20*500 = 10000 Rs
2. 2 Rollers of diameter 21 cm (For conveyor belt for washing) and 5 rollers of diameter 9 cm (For conveyor belt for drying) together cost 15*2 + 3*5 = 45000 Rs
3. The conveyor belt for washing (5m) along with the conveyor belt for drying (square root(5) + 1 m = Approximately 3.25m) cost around 38000 Rs
4. Exhaust, heating elements and duct Cost approximately 6000 Rs
5. 2 Motors for the two conveyor belts together cost 2*5000 = 10000 Rs
6. Final assembly cost 6000+2500 = 8500 Rs

4.4 Performance Specifications

4.4.1 Chemicals used for washing

1. **Soft or Hard Water Considerations:** To address water hardness, our design incorporates soda ash for effective water softening. Estimations for soda ash usage are tailored to the water hardness levels to ensure optimal washing performance [7].

2. **Estimation for soda ash usage:** Depending on the water hardness, ranging from light to hard, we adjust soda ash usage accordingly, with a price of Rs 40 per kg.

3. **Safety Standards and Environment Guidelines:** Our washing machine design adheres to safety and environmental sustainability standards, ensuring compatibility with Surf Excel detergent [5].

4.4.2 Water Nozzles

1. **Nozzles for the main wash:** High-impact flat fan nozzles or tongue-type nozzles are recommended for the main wash. The spray angle should be 30 to 45 degrees, ensuring a sharp jet suitable for low pressure. These nozzles have a longer service life due to their hardened nozzle mouthpiece [4].

2. **Nozzles for rinsing:** Rinsing requires nozzles that produce small droplets for quick runoff. Flat fan nozzles with a very low flow rate are suitable for this stage.

4.4.3 Drying

The total heat required to turn m mass of water (in Kg) into water at 100 degrees is ms(100-20) (Where s is the specific heat capacity of water, assuming that after washing, the water temperature is 20 degrees Celsius.) To turn it into steam, we need an extra mL Joules of Energy, where L is the latent heat of vaporization. As we use sponge rollers before they enter the drying chamber, which squeezes out most of the water, let's assume the worst case, where 5 kg of water is left back on an 11 Kg dry cloth. The total energy required is: $5000*4.186*80+5*2.25*10\hat{6} = 12924400$ J or 12,924.4 kJ. For time, divide this by the power the heating element provides, which is 5 Kilo Watts. So, the total time required is 12,924.4/5 sec., i.e. Approx 43 Mins.

4.4.4 Drainage System

1. **Valve Size:** The valve diameter should be 2-3 inches, made of stainless steel or corrosion-resistant plastic, and located at the lowest point downstream of the wash chamber.

2. **Material and Durability:** The drainage system should use HDPE or PVC materials with a diameter matching the valve size, sloped towards the valve for efficient drainage.

3. **Parameters for Drainage System Design:** The design should account for residential and commercial flow rates, with a focus on peak flow handling and accessibility for maintenance.

4.5 Manpower Specifications

The tribe coordinators spent around 18 hours each in this week's submission coordinating with the different teams and reviewing their work.

Name	Entry No.	Working Hours
Bhumi Gadhavi	2021MT60950	8
Tanmay Jhalani	2021EE30389	1
Shantanu Pandit	2021MT10252	1
Pramsu Shrivastava	2021EE10140	5
Parth Naikwad	2021EE10672	5
Yash Bafna	2021EE10660	1
Abhay Yadav	2021EE10151	5
Ram Gopal Chaudhari	2021EE10671	1
Vivek Pratap Singh	2021EE10687	5
Shreya Gupta	2021MT10906	3
Vaibhav	2021EE10641	5
Devanshu Ataria	2021EE10162	5
Anmol Bansal	2021EE10643	5
Vedant Patel	2020EE10520	1
Aditi Srivastava	2021MT10228	1
Anusha Kedawat	2021EE30718	1
Manan Singal	2021EE10138	1
Tanisha Chouhan	2021EE10693	1
Vedant Kokate	2021EE10631	5
Subham	2022MT11823	5
Himanshu Ghusinga	2021MT10936	1
Ranjeet Mishra	2021EE10656	1
Siddharth	2022MT62028	3

Table 10: Design Team work-hour estimation

The research team members gave an average of 8 hours for this week's submission. The work included researching on the assigned topics by the activity coordinator and then presenting and refining their work to finalise the machine specifications. These 8 hours also include the time spent in meetings and generating Zotero files for the final submission. The activity coordinators spent around 15 hours on the submission. We have 19 members and 2 activity coordinators in the research team, so the man hours is nearly 182 for the research team.
Competency/ skillset required- The research team members required excellent comprehension skills to be able to enhance the reading capabilities of the tribe. They were also required to learn to generate their references using Zotero. The design team was divided into subteams, electrical and mechanical. The electrical subteam was trained for Arduino programming, PCB designing and soldering. The mechanical team was trained for CAD designing in FreeCAD and laser cutting.
Surplus manpower-During the initial days only some of the members of design team were collaborating with the research team to come up with the final design for the cleaning machine while the others were underutilised. However towards the end they were fully involved with the freeCAD designing of the final assembly.

Name	Entry No.	Working Hours
Keshav Singhal	2021EE10788	15
Advait Prashant Rege	2021MT60946	15
Rishika Goel	2021EE30725	6
Ridhima Gupta	2021EE30719	8
Diksha	2021EE30717	8
Tushar Daima	2021EE10688	8
Ridam Kumari	2021EE10158	8
Harsh Bagde	2021EE10690	8
Nidhish	2021EE30176	4
Priyal Jain	2021MT60949	7
Aditya Thomas	2021MT60944	7
Pratibha Patel	2021EE10681	8
Divyansh Bhatnagar	2021EE30721	8
Siddhika Tailor	2021EE10683	8
Narendra Nath Sharma	2021EE10695	4
Stuti Anand	2021EE30748	6
Anish Gupta	2021EE10663	7
Dhruv Mittal	2021EE10626	8
Mridul Jagrat	2021EE30182	7
Abhishek Meena	2021EE10172	4.5
Kinshuk Bansal	2021EE30701	2

Table 11: Research Team work-hour estimation

Name	Entry No.	Working Hours
Shourya Vir Jain	2022EE31798	3
S Anuj Karthik	2021EE10667	2.5
Shreya Singla	2020EE10671	3
Gourab Raj Sabat	2022EE11675	3
Ashi Veerman	2021MT10241	3
Bhargab Sonowal	2021MT10937	3
Rakshitha	2021MT10904	2.5
Sanju N S	2021EE30732	2.5
Dhruv Joshi	2022EE32079	3
Drishti Gupta	2021EE10649	3
Praveen Kumar Srivastava	2021EE10133	0
Deepak Kumar	2021EE10152	0
Varshith Reddy Ryala	2021EE10142	2.5
Raswanth J	2021EE30179	3
Prisha Jain	2021EE30330	2.5
Garv Gupta	2021MT60953	2.5
Sanjay Karela	2012MT50616	0
Dhruv Nagpal	2020EE11013	3

Table 12: Documentation Team work-hour estimation

4.6 Prototype Specifications

Because of the limitations of available smaller standard parts, a lot of the dimensions could not directly be scaled down by a factor of 10.

4.6.1 Motor

We are assuming (1/100) volume and weight of our machine, as per our dimensionality calculations.

1. The total weight being driven is 2 kgm/min
2. The total weight of the belt ranges from 15-30 kg.
3. The motor will run at 0.001 horsepower.
4. The energy requirements are for 0.0005 kWh per motor.

4.6.2 Drying

The power required for drying will be around 500 - 800 watts.

4.6.3 Exhaust

The exhaust system requires a voltage of 240V and a power wattage of 10 - 16 Watts.

4.6.4 Conveyor belt

1. The conveyor belt is made of general-purpose rubber with a density of $1150\,\mathrm{kg\,m^{-3}}$.
2. The length of the belt is 2 meters due to a larger estimation of washing and drying size.
3. The width of the belt is 26 centimetres to leave slack for cloth.
4. The thickness of the belt ranges from 3 to 5 mm.

4.6.5 Machine Dimensions

1. The machine is 26 centimetres wide.
2. The height of the conveyor belt is 30 centimetres.
3. The length of the machine is 70 centimetres, divided into a 50-centimeter conveyor belt for washing and a 20-centimeter-long drying compartment.

4.6.6 Chemicals cost

We will use 50 millilitres of detergent and 30 grams of soda leading to a cost of 14.2 rupees.

4.6.7 Heating elements cost

The cost of heating elements will be 1800 rupees per kilogram.

4.6.8 Drainage System Performance

1. The valve diameter should be 2-3 centimetres.
2. There will be a use of 2 - 4 centimetres of material with the same diameter as the valve.
3. The chosen flow rate is 50 litres per minute.

Milestone	Description	TRL
1	Practical applications can be invented once basic principles are observed.	TRL-2
2	Active research and development is initiated, including analytical studies and laboratory studies.	TRL-3
3	The basic components of the technology are integrated to establish that the pieces will work together.	TRL-4
4	Representative model or prototype system is tested in a relevant environment.	TRL-6

Table 13: Milestone TRL Levels

4.7 Milestone Specifications

4.7.1 Milestone 1

Develop a comprehensive Computer-Aided Design (CAD) model that precisely outlines the trajectory of the cloth within the cleaning machine.
TRL-2: Practical applications can be invented once basic principles are observed.

4.7.2 Milestone 2

Refine the CAD design to incorporate well-defined structures for seamless integration of auxiliary components, such as water and chemical inputs, and an efficient drainage system.
TRL-3: Active research and development is initiated, including analytical studies and laboratory studies.

4.7.3 Milestone 3

Synthesize the comprehensive CAD model with the intricate electrical system and circuitry required for the cleaning machine. Electrical assembly and designing of HMI.
TRL-4: The basic components of the technology are integrated to establish that the pieces will work together.

4.7.4 Milestone 4

Fabricate the final prototype of the cleaning machine, incorporating all finalized CAD designs and electrical components.
TRL-6: Representative model or prototype system is tested in a relevant environment.

5 Specifications - Engineering Drawings

The main components of our machine include the following:

1. **Nozzle** - The component that directs the flow of water.
2. **Washing Conveyor** - This moves the laundry through the wash cycle.
3. **Drying Conveyor** - Responsible for the removal of moisture post-wash.
4. **Final Assembly** - Where all parts are assembled into the final product.

Detailed drawings of these components are presented from the next page.

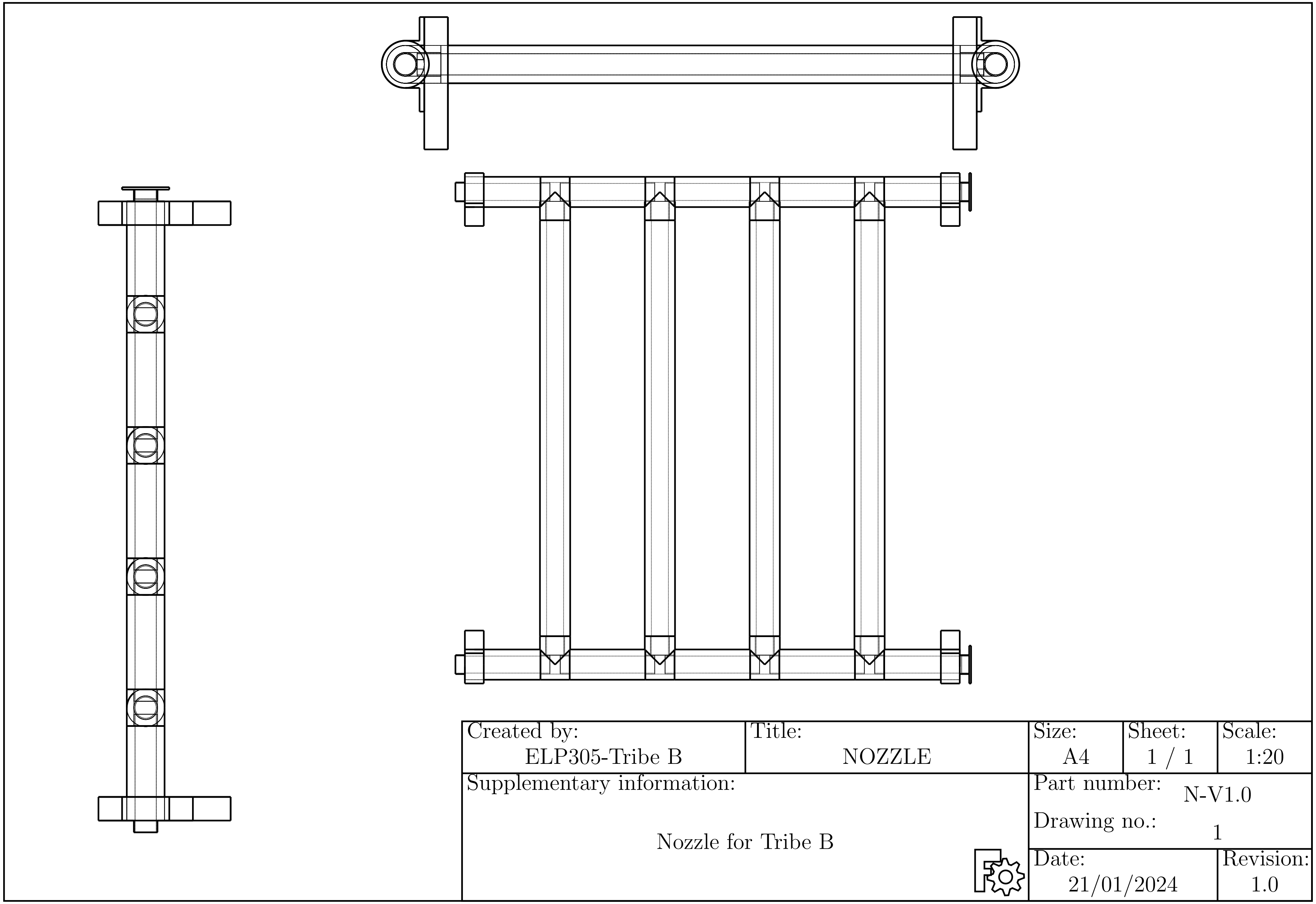

Figure 6: Engineering Drawing for Nozzle

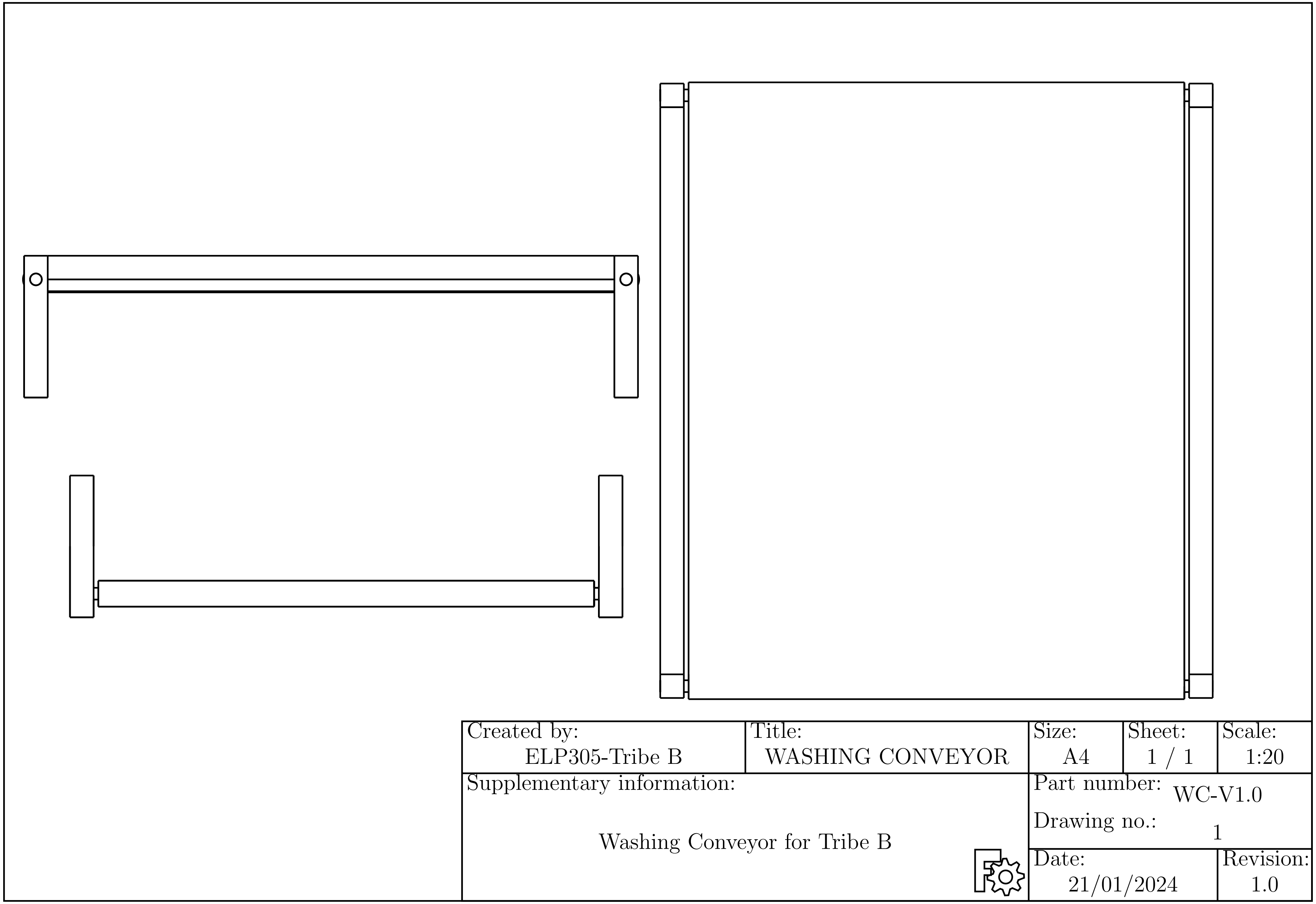

Figure 7: Engineering Drawing for Washing Conveyor

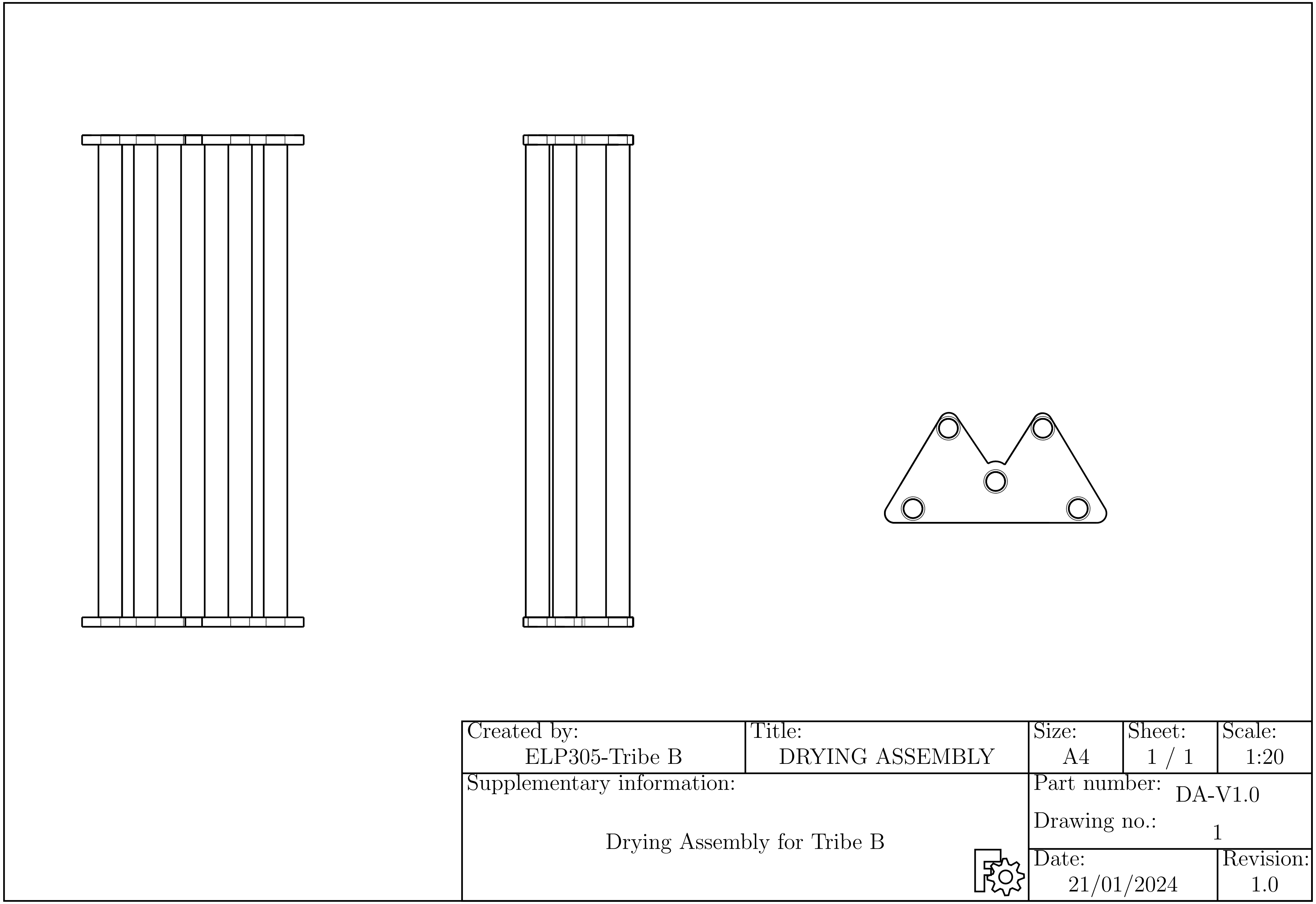

Figure 8: Engineering Drawing for Drying Conveyor

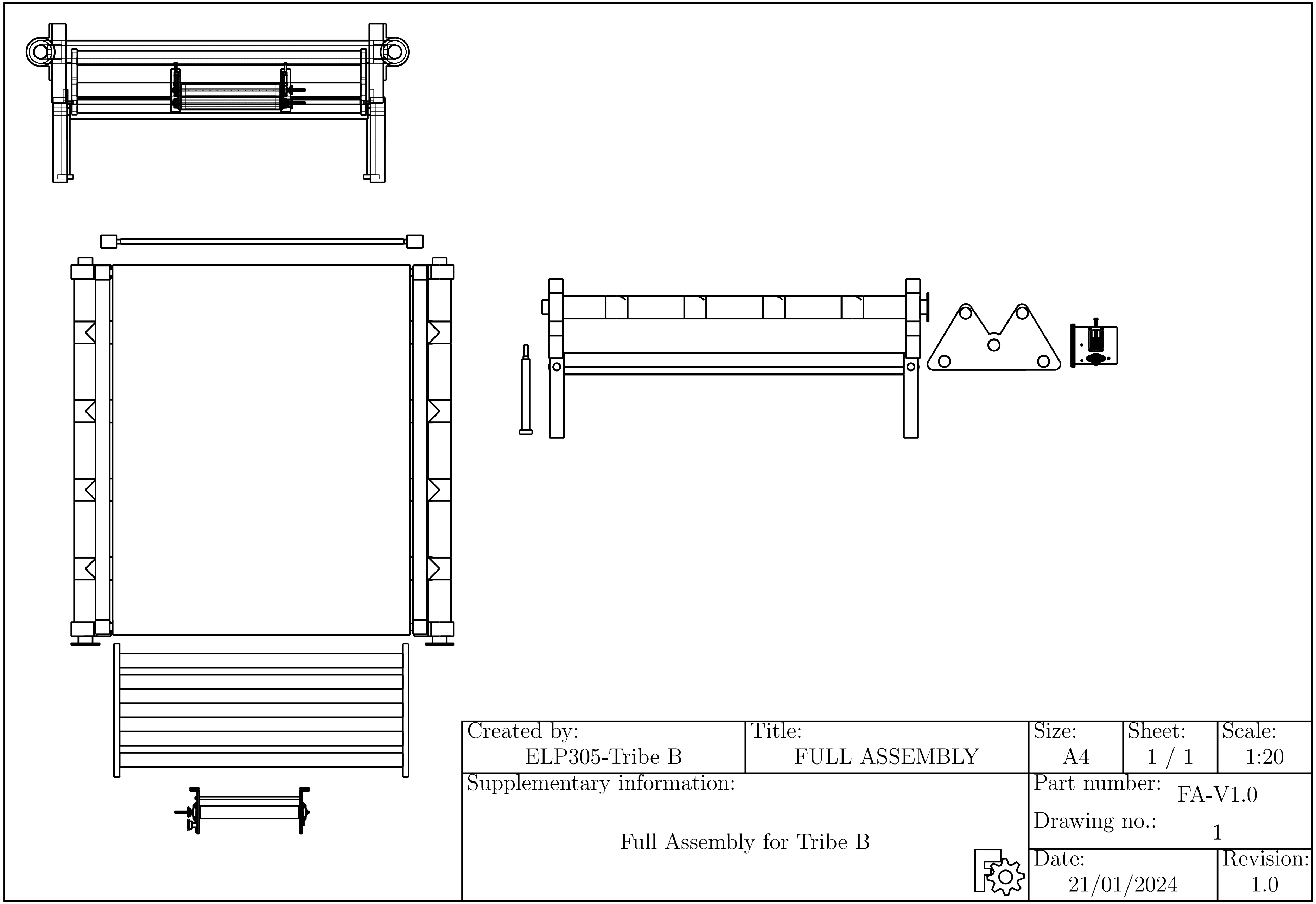

Figure 9: Engineering Drawing for Assembly

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Acronyms

AC Activity Coordinator. 1, 2

CAD Computer-Aided Design. 29

CFM Cubic Feet Per Minute. 15

CPCB Central Pollution Control Board. 13

HDPE High Density Polyethylene. 24

HMI Human-Machine Interface. 5, 9, 18, 29

IF Involvement Factor. 1–4, 7

PERC Perchloroethylene. 20

PLC Programmable Logic Controller. 4, 9, 18

PVC Polyvinyl Chloride. 24

TC Tribe Coordinator. 1

TRL Technology Readiness Level. 7, 29

WBS Work Breakdown Structure. 7, 10

Glossary

abrasion resistance Abrasion Resistance refers to the ability of a material to withstand wear, rubbing, or friction, maintaining its surface integrity and resisting damage caused by repeated contact with abrasive forces or surfaces. 14

Access panels A removable panel on a machine that allows for access to its internal components for cleaning or maintenance. 18

back-folded seams A type of seam where the raw edges of the fabric are folded back and sewn together. 14

cleaning efficacy The effectiveness of a cleaning process in removing dirt, stains, and other contaminants from fabrics. 9, 12, 18

denier Denier is a unit of measurement for the linear mass density of fibers, indicating the weight in grams of a 9,000-meter length, commonly used to express the thickness or fineness of yarn in the textile industry. 9, 14

effluent treatment The process of removing pollutants from wastewater before it is released back into the environment. 5, 19

seam slippage Seam spillage is the undesired leakage of contents through container seams due to inadequate sealing, posing a risk of material loss. 14

tear strength Tear Strength is a measure of a material's resistance to tearing or the force required to propagate a tear, indicating its durability against the initiation and growth of a tear or cut. 9, 14

tensile method test A test that measures the breaking strength of a fabric by pulling it until it breaks. 14

thread count The number of threads woven into a square inch of fabric. 9, 14

tumble drying process A drying method that uses a rotating drum to circulate hot air around fabrics. 9, 16

wet cleaning agent A detergent or solvent specifically designed and used for wet cleaning. 15, 16, 18

Index

A Appendix 1: Document ID

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B Appendix 2: Document Statistics

- Word Count: 7993
- Number of Sentences: 1139
- Number of Characters: 41089

C Appendix 3: Readability Indices

- **Readability Index[1]:** 3.3
  This means that this text can be understood by children who can read books with chapters.
- **Gunning-Fog Index[2]:** 8.1
  This means that the text can be easily understood by someone who has passed grade 8, US education standards.
- **Flesch Reading Ease[3]:** 57.1
  This means that this text can be understood by 12-13 year olds.
- **Coleman Liau Index[4]:** 10.1
  This means that the text can be easily understood by someone who has passed grade 10, US education standards.

[1] The readability index indicates the approximate reading grade level of a text based on the US education system. The formula takes into account characters in a given word and the words in a given sentence. It varies from 0 - 16+.

[2] On a scale from 0 -20, the Gunning-Fog Index is a weighted average of the number of words per sentence and the number of long words per word. This can be understood as the text can be understood by someone who left full-time education at a later age than the index. Hence a lower Gunning-Fog index is easier to read.

[3] The Flesch Reading Ease indicates the approximate reading grade level of a text. The formula takes into account sentence length and word length. It is based on a 0-100 scale. A high score means that the text is easier to read.

[4] On a scale of 0 - 17+, the Coleman Liau Index relies on characters and calculates the index based on the number of characters in a word and the number of words in a sentence. The score of the text indicates the US school level a person needs to understand the text.